

REDUCING MB DOSAGE OR EXPOSURE TIME USING CO₂ WITH MB OR CO₂ WITH HEAT

S. Navarro*, E. Donahaye, Glory C. Sabio, Miriam Rindner, R. Dias and A. Azrieli

Department of Stored Products, Agricultural Research Organization,
The Volcani Center, P.O.Box 6, Bet Dagan 50250, Israel
e-mail: vtshlo@netvision.net.il

Abstract

This study was undertaken to investigate the effect of methyl bromide (MB) in combination with CO₂ with the objective of reducing MB dosages to minimum effective levels, and consequently minimizing MB emissions. In addition, a combination of CO₂ with heat as an alternative treatment to MB was investigated. Dosage levels were investigated using all four developmental stages of the almond moth, *Ephestia cautella* (Walker). For control of the egg stage, the influence of CO₂ in reducing the effective MB concentration, expressed as *concentration x time* (CTp) in mg.h/L, was marginal, but it was most pronounced for larvae, pupae and adults. Addition of CO₂ decreased the MB CTp values to half for larvae and pupae, and to one third for adults when compared with MB without CO₂. The influence of CO₂ at 40°C on reducing the exposure time expressed as LT₉₅ (hours to obtain 95% mortality) values for *E. cautella* showed that the most sensitive stage was the adult, and the least sensitive stage was the pupae. Increasing the CO₂ concentration to 80% decreased the exposure time to about 10 hours for the resistant pupal stage. These results demonstrate the potential use of CO₂ in combination with heat or with MB as an alternative control method to MB alone.

Keywords: *Ephestia cautella*, tropical warehouse moth, modified atmospheres, CO₂, MB, heat treatment.

INTRODUCTION

There is a large variety of suggested potential alternatives to MB for disinfestation of durable commodities. Development of these alternatives is likely to be costly. Under present agreements of the Montreal protocol, there are exemptions for all countries from controls on MB when used for quarantine and pre-shipment fumigations, and for some critical agricultural uses, yet to be defined.

The gradual development of insect resistance to fumigants and the undesirable effects of fumigant residues in food led to the idea of using mixtures containing CO₂. The toxicity to insects of CO₂-MB mixtures was found to increase by a factor of two to three. A system based on this technology is in use in Israel for the disinfestation of dates. By using a

CO₂/MB mixture making 20% CO₂, the normal amount of MB required is reduced by about 50%.

The potential use of CO₂ as an alternative to methyl bromide is limited by the long exposure periods required to produce complete mortality at normal ambient temperatures. These periods are similar to those required for phosphine fumigations. In cases where rapid disinfestation of commodities is required, the possibility of using CO₂ at temperatures raised to levels that will not adversely affect the commodity should be considered. Insect development and metabolism are positively correlated with temperature, and it is long accepted that insecticide treatments, particularly those affecting the respiratory system are more pronounced at higher temperatures.

The objectives of this investigation were to develop dosage schedules to reduce emissions of MB when applied in combination with CO₂ and to develop an alternative treatment method based on a combination of heat and CO₂.

MATERIALS AND METHODS

CO₂-MB mixtures:

Carbon dioxide concentrations of 0, 10 and 20% in air served as a basis for testing different MB concentrations. For all fumigations the RH in the exposure chamber was maintained at 70% and the exposure temperature was 30°C.

CO₂/ heat combinations:

Temperatures for testing the sensitivity of insects were 35, 40 and 45°C in combination with CO₂ mixtures in air of 0, 60, 70, 80 and 90%.

Test Insects: The four developmental stages (eggs, larvae, pupae and adults) of the almond moth (= the tropical warehouse moth), *Ephestia cautella* (Walker) were used.

Experimental procedures:

Prior to each test, 50 larvae, pupae or adults each were confined separately, in small perforated plastic cages. For eggs, oviposition batches containing a minimum of 40 eggs were similarly caged. Insects were exposed to the fumigants in 3.5-liter glass chambers. The 95% mortality values were estimated by plotting results on a Probit-log paper to obtain best fit mortality line.

RESULTS AND DISCUSSION

The influence of CO₂ on reducing the MB concentration for control was assessed by calculating values of *concentration x time* (CTp) as expressed in mg.h/L. CTp values of MB at the LC₉₅ for *Ephestia cautella* eggs, larvae, pupae and adults at 30 °C are shown in Fig. 1. In this study the exposure times for calculating CTp values varied from 4 to 16 h. According to Fig. 1 the influence of CO₂ in reducing the CTp values for the control of the egg stage was marginal, but it was most pronounced for larvae, pupae and adults. The reason for the significant difference in response by the egg stage could be due to respiration taking place by diffusion through the shell, unlike the other developmental stages that are equipped with

spiracles to regulate gas exchange. Addition of CO₂ decreased the MB CTP values to half for larvae and pupae and to one third for adults compared with the control without CO₂.

The influence of CO₂ on reducing the exposure time as expressed in LT₉₅ (hours to obtain 95% mortality) values for *Ephestia cautella* eggs, larvae, pupae and adults at 40 °C is shown in Fig. 2. The most sensitive stage was the adult and the least sensitive was the pupae. Larvae and egg stages responded similarly. Increasing the CO₂ concentration to 80% decreased the exposure time to about 10 hours for the most resistant stage, the pupae. These results demonstrate the potential use of CO₂ in combination with heat as an alternative control method to MB. More storage insects are under investigation to demonstrate the feasibility of this method.

ACKNOWLEDGMENT

This research was supported by a grant from the USISTF, (the United States-Israel Science and Technology Foundation, ARO Project #-5288).

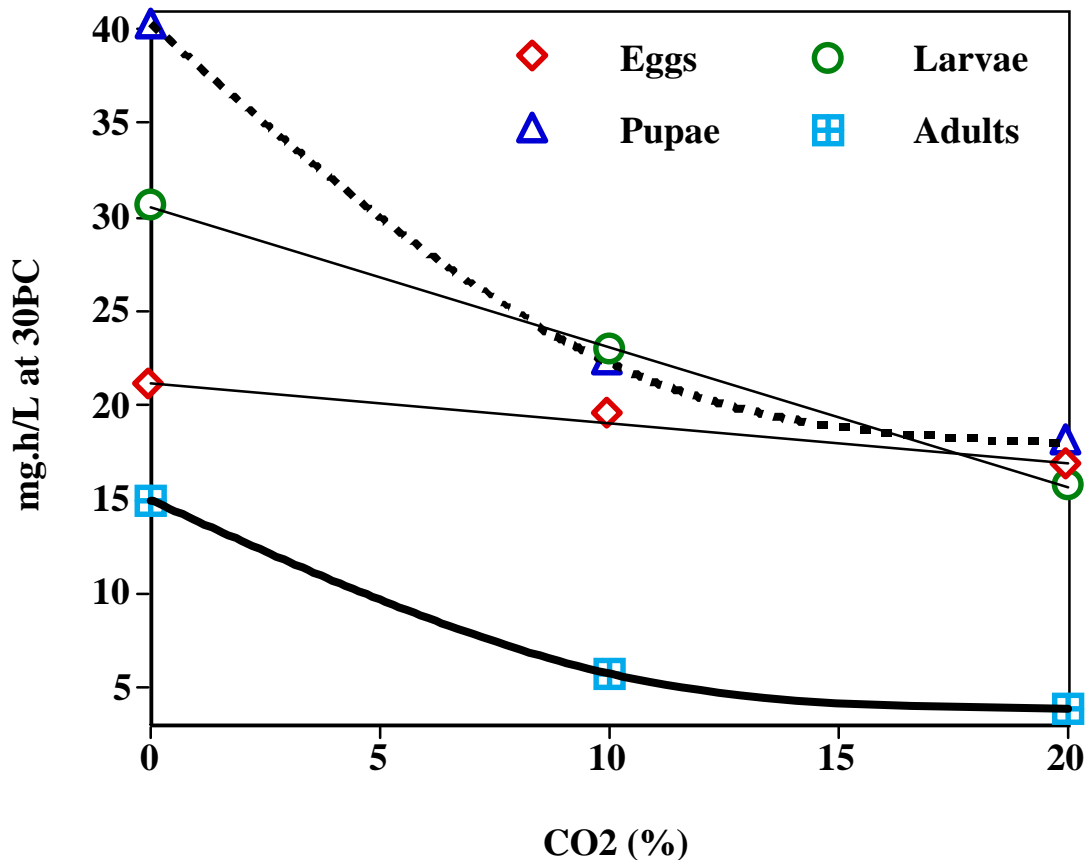


Fig. 1 - The influence of CO₂ on reducing the CTP as expressed in mg.h/L of MB to obtain 95% mortality of *Ephestia cautella* eggs, larvae, pupae and adults at 30 °C. Exposure times for calculating CTP (concentration \times time) varied from 4 to 16 h.

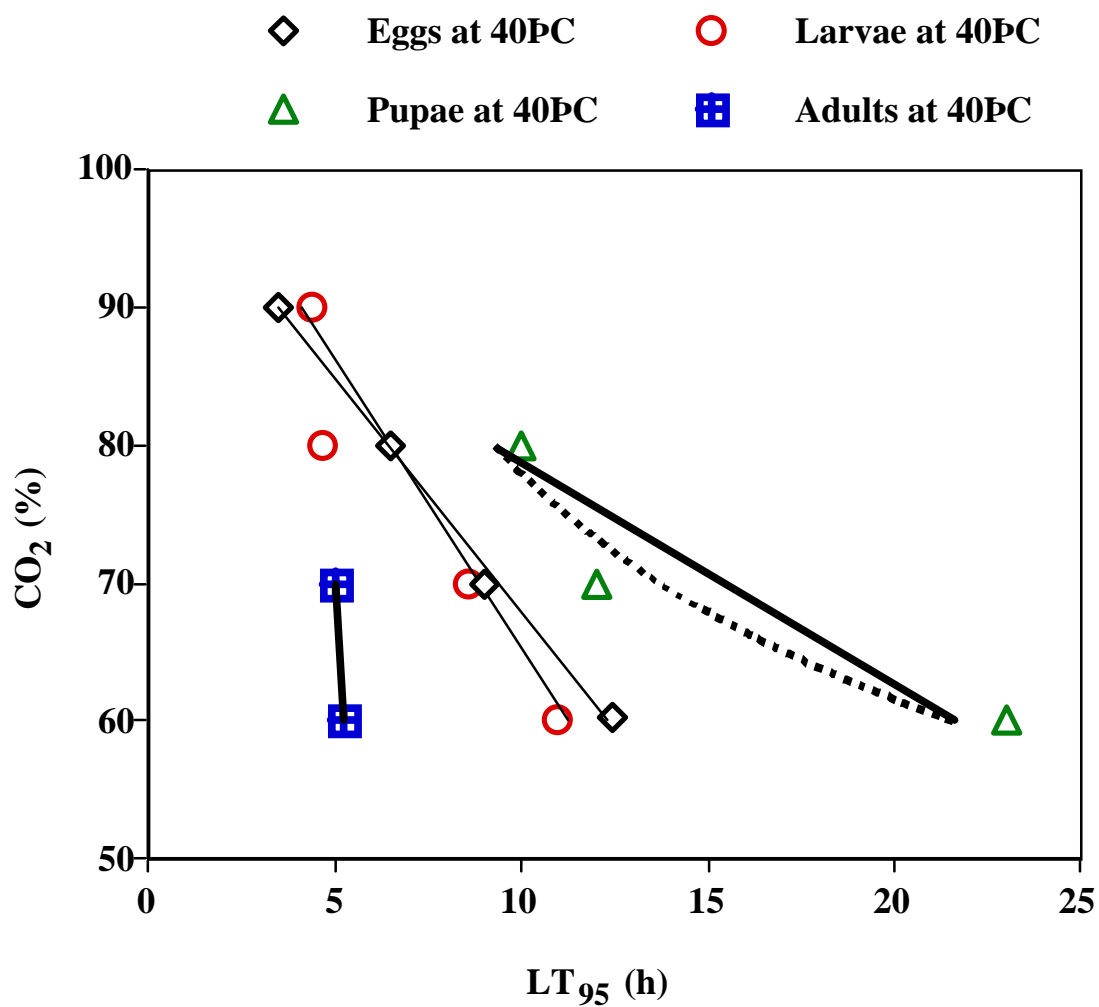


Fig. 2 - The influence of CO₂ on reducing the exposure time as expressed in LT₉₅ (hours to obtain 95% mortality) values for *Ephestia cautella* eggs, larvae, pupae and adults at 40 °C.